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Creosote

Health and Environmental Effects

U.S. ENVIRONMENTAL PROTECTION AGENCY
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DISCLAIMER

This report represents a survey of the potential health and environmental hazards from exposure to the subject chemical. The information contained in the report is drawn chiefly from secondary sources and available reference documents. Because of the limitations of such sources, this short profile may not reflect all available information including all the adverse health and environmental impacts presented by the subject chemical. This document has undergone scrutiny to ensure its technical accuracy.

SPECIAL NOTATION

U.S. EPA's Carcinogen Assessment Group (CAG) has evaluated creosote and has found sufficient evidence to indicate that this compound is carcinogenic.

CREOSOTE

I. INTRODUCTION

Creosote is a coal-tar distillate used mainly as a wood preservative. It is highly toxic to wood-destroying organisms and has a low evaporation rate (Farm Chemicals Handbook, 1977). In 1972, an estimated 521,000 tonnes (575,000 tons) were produced by six companies at 25 sites in the United States (von Rumker, et al. 1974). About 90 percent of the creosote is sold to the wood-preservation industry; the remainder is burned as fuel (von Rumker, et al. 1974).

Creosote's other pesticidal uses are as an herbicide, an insecticide, an acaricide, an arachnicide, a fungicide, a tree dressing, a disinfectant, and a horse repellent (Table 1).

TABLE 1.

USES AND SITES FOR CREOSOTE
(Cummings, 1977)

Use	Site
Preservative	Wood
Insecticide (screwworm)	Horses and mules
Acaricide (mites)	Poultry and horses
Arachnicide (ticks)	Poultry and horses
Herbicide	Along roads, highways, and fences; farms; flower beds
Fungicide	Rope, canvas, tarpaulins, tree wounds
Insecticide (Certain insects, worms, moths and borers)	Tree dressing
Horse repellent	Wood stalls, mangers, gates, fence rails, posts, trees, trailer sites
Disinfectant	Outhouses, water closets, garbage cans, feeding and watering equipment

Creosote is produced by the distillation of coal tar obtained from the coking of coal. The composition of creosote is highly variable and depends on the composition of the coal used to make the tar, the design and operating conditions of the coke oven (e.g., gas collection system, temperature, coking time), and the design and operating condition of the still (e.g., feed rate, temperature, and blending of tar distillation fractions) (43 FR 48154, 1978).

Continuous tar distillation at temperatures of up to 400°C produces fractions typically ranging from crude benzene to residue pitches (von Rumker, et al. 1974). A common distillation temperature for creosote is about 200 to 400°C (Hawley, 1977; von Rumker, et al. 1974). The creosote fraction is a mixture of organic compounds, mainly liquid and solid cyclic hydrocarbons, including two-ring and polynuclear aromatic hydrocarbons (PAH) (Table 2). Among the PAH, phenanthrene represents 12 to 14 percent of the composition of creosote (Considine, 1976). Benzo(a)pyrene (BaP) is present at a concentration of about 200 ppm (Guerin, 1977).

II. EXPOSURE

A. Water

Each year an estimated 60 to 115 million pounds (27,000-52,000 tonnes) of creosote are discharged in wastewater treatment sludges by creosote producers. At large tar distillation plants, wastewater streams containing creosote are treated on-site and/or conveyed to public sewage treatment facilities. Wastewater sludges treated on-site are transferred to landfill or burial sites (von Rumker, et al. 1974). The estimated flux of creosote from these disposal sites ranges from 0.75 $kg/m^2/hr$ to 11.0 $kg/m^2/yr$ (U.S. EPA, 1980). In 1972, about one billion pounds (455,000

TABLE 2.

PHYSICAL AND CHEMICAL PROPERTIES OF CREOSOTE

Synonyms: Brick oil, coal tar oil, creosote oil, creosotum, cresylic creosote, dead oil, heavy oil, liquid pitch oil, naphthalene oil, tar oil, wash oil

Structural and Empirical Formula: Consists principally of liquid and solid cyclic hydrocarbons; contains substantial amounts of naphthalene and anthracene; 12-14 percent phenanthrene; 200 ppm benz(a)pyrene

Molecular Weight: ---

Description: Dark brown green, yellowish or colorless above 38°C, naphthenic odor; soluble in alcohol, benzene toluene; immiscible with water

Specific Gravity and/or Density: d^{25}_{25} more than 1.076

Melting and/or Boiling Points: Common distillation range 200 to 400°C

Stability: Overall degradation rate (0.48/day) = same as microbial degradation

Solubility (water): approx. 5 g/l; $\frac{sed}{H_2O} \cdot \frac{.2}{1}$

Vapor Pressure: ---

Bioconcentration Factor (BCF) and/or Octanol/water partition coefficient (K_{ow}): BCF = 0.6
K_{ow} = 1.0

Source: Hawley, G.G., 1977; Windholz, 1976; U.S. EPA, 1980; Lopedes, 1978 tonnes) of creosote were used to preserve railroad ties, marine pilings and utility poles (NIOSH, 1977a).

Some of the organics present in creosote are moderately soluble. Creosote partitions between sediments and water in a ratio of 1:5. It is considered stable in groundwater, but decomposes at an estimated rate of 90 percent in five days in river water flowing 50-250 miles. About 99 percent decomposed in a lake environment in one year (U.S. EPA, 1980).

Creosote migrates from treated wood into the environment, but the impact of this migration is unknown. Creosote was found to have a vapor loss of 27.5 and 15.2 percent from the outer two inches of seasoned and green poles, respectively; high residue creosote was estimated to have a 10.3 and 4.4 vapor loss, respectively. Creosote losses to the aquatic environment are the greatest during the first years after installation. One eight-year study is summarized below (43 FR 48154, 1978).

Year	Creosote Loss pounds/linear foot
1	0.31
2	0.05
3	0.06
4	0.22
4-8	0.15 (average)

B. Food

Naiussat and Auger (1970) found that PAHs in a contaminated lagoon accumulated to the greatest extent in species near the top of the food chain. One of these compounds, BaP, has been reported to accumulate in mussels (about 50 μg/kg; 20 times background) taken from creosote-treated pilings (43 FR 48154, 1978). Elevated levels of BaP in mussels growing near creosoted timbers or pilings suggest that creosote is a significant source of BaP in the marine environment. This suggestion was supported by comparisons of gas chromatography profiles of polycyclic aromatic hydrocarbons isolated from mussels and creosoted wood (Dunn and Stich, 1976).

High levels of PAH have been found in commercial seafoods grown in impoundments constructed of creosoted wood. Commercial samples of oysters, clams, and mussels were found to contain BaP at concentrations generally less than 10 ng/g (wet weight). PAHs were also found in cockels, abalone, scallops, lobster, and shrimp. Levels of BaP and other related PAHs were found to be inversely related to the ability of the species to metabolize PAH, except in the case of lobster. Unexpectedly high levels were found in all edible meat of lobsters maintained in commercial tidal compounds constructed of creosoted timber: up to 281 ng/g BaP, 303 ng/g chrysene, 222 ng/g benzo(a)anthracene, 261 ng/g benzo(b)fluoranthene, 153 ng/g dibenz-(a,h)anthracene, and 137 ng/g indeno(1,2,3-cd)pyrene (Dunn and Fee, 1979).

III. PHARMACOKINETICS

A. Absorption

Creosote is (readily) absorbed through the skin and mucous membranes (NIOSH, 1977b).

IV. EFFECTS

A. Carcinogenicity

Creosote has been associated with several occupational cases of skin cancer over a 50-year period (Farm Chemicals Handbook, 1977); its role in human cancer is still not clearly understood (NIOSH, 1977b).

Henry (1947), Lenson (1956), O'Donovan (1920), Cookson (1924), and Mackenzie (1898) described various kinds of workers who were occupationally exposed to creosote and developed skin tumors. Dermal application of creosote produced skin tumors in mice (Woodhouse, 1950; Poel and Kammer, 1957; Lijinsky, et al. 1956; Boutwell and Bosch, 1958; Roe, et al. 1958). Roe, et al. (1958) also found that dermal application of creosote to mice produced lung tumors. Boutwell and Bosch (1958) found that creosote had the ability to initiate tumor formation when applied for a limited period prior to treatment with croton oil. Sall and Shear (1940) found that the number of skin tumors was increased by dermal treatment with creosote and benzo(a)pyrene over the number of tumors produced by benzo(a)pyrene or creosote alone. There is considerable evidence to show that creosote produces tumors in mice; that creosote, when applied dermally, is a tumor-initiating agent when followed by dermal treatment with croton oil (Boutwell and Bosch, 1958); that creosote accelerates the tumor production caused by benzo(a)pyrene (Sall and Shear, 1940); and that workers occupationally exposed to creosote developed tumors (Table 3). These studies have not yet demonstrated a correlation between the carcinogenic potency of creosote oils and the content of benzpyrene (Patty, 1963).

Results from dose response studies are summarized below (NIOSH, 1977a).

Concentration and duration	Effects
100% 3x/wk 28 wk	Skin carcinomas in 82%, tumors in 92%
20-80% 3x/wk 6-44 wk	Skin carcinomas in 88%, tumors in 100%
100% 2x/wk 21 wk	Skin and lung tumors in 74%
100% 3x/wk 70 wk	Skin tumors in 50%
10-100% 2x/wk* 70 wk	Skin tumors in 38-74%
2% 2x/wk* 70 wk	No tumors

*Creosote plus 1 percent 7,12-dimethylbenz(a)anthracene.

TABLE 3.

SUMMARY TABLE ON ONCOGENICITY OF CREOSOTE

A. Human Case Reports

Authors	Year	Substance and Type of Exposure	Occupation of Exposed Individual(s)	Type of Tumor Response
Mackenzie	1896	Handling of Creosote	Worker who dipped railway ties in creosote	Warty elevation on arms; papillomatous swellings on scrotum
O'Donovan	1920	Handling of Creosote	Workers who creosoted timbers	Skin cancer
Cookson	1924	Handling of Creosote	Creosote factory worker	Squamous epitheliomata on hand; epitheliomatous deposits in liver, lungs, kidneys and heart walls
Henry	1947	Handling of Creosote	37 men of various occupations	Cutaneous epitheliomata
Lenson	1956	Painting of Creosote	Shipyard worker	Malignant cutaneous tumors of the face

B. Animal Studies

Dermal Exposure

Authors	Year	Substance Tested	Animal and Strain	Type of Tumor Response
Sall and Shear	1940	Creosote and benzo(a)pyrene	Mice (Strain A)	Accelerated tumor formation
Woodhouse	1950	Creosote oil	Mice (Albino; Undefined strain)	Papillomas and carcinomas
Lijinsky, et al.	1956	#1 creosote oil	Mice - Swiss	Papillomas and carcinomas
Poel and Kammer	1957	Blended creosote oils;	Mice (C57L Strain)	Papillomas and carcinomas metastatic growths in lungs and lymph nodes
		Light creosote oil	Mice (C57L Strain)	Papillomas
Boutwell and Bosch	1958	Creosote (Carbasota)	Mice (Albino - random bred)	Papillomas and carcinomas
Roe, et al.	1958	Creosote oil (Carbasota)	Mice (Strain Undefined)	Skin and lung tumors

B. Mutagenicity

Simmon and Poole (1978) found that, following metabolic activation by Arochlor 1254-stimulated rat liver homogenate, both the creosote P1 and the coal tar-creosote P2 produced a mutagenic dose-response and a doubling above background mutation rate with Salmonella typhimurium strains TA 1537, TA 98, and TA 100. Mitchell and Tajiri (1978) found that, following metabolic activation by Arochlor 1254-stimulated rat liver homogenate, creosote P1 and coal tar creosote P2 increased the number of forward mutations at the thymidine kinase locus of L5178Y mouse lymphoma cells in a dose-related manner. There is considerable evidence which proves that creosote P1 and P2 cause mutations in Salmonella typhimurium strains TA 1537, TA 98 and TA 100, and in L5178Y mouse lymphoma cells.

C. Teratogenicity and Other Reproductive Effects

Investigations utilizing pregnant swine indicate that direct contact with lumber freshly treated with creosote would produce acute toxicosis, resulting in extensive mortality in newborn swine. The direct contact of the pregnant sow with lumber freshly treated with creosote provides sufficient dermal absorption to cause fetal deaths and weak pigs at birth. Creosote is extremely toxic to young swine; the degree of toxicity lessens as the pigs become older (Schipper, 1961).

D. Chronic and Acute Toxicity

Skin contact with creosote or exposure to its vapors may cuase burning, itching, papular and vasicular eruptions, or gangrene. Eye injuries can include keratitis, conjunctivitis, and corneal abrasion (Patty, 1963). Exposed skin shows increased susceptibility to sunburn, an effect attributed to photo-toxic substances usually present in commercial grades of creosote. Eventually, exposed skin areas become hyperpigmented (NIOSH, 1977b).

Serious systemic effects, including cardiovascular collapse and death, have been observed only after ingestion (NIOSH, 1977b). Fatalities have occurred within 14 to 36 hours after ingestion of 7 grams by adults or 1 to 2 grams by children. Symptoms of systemic illness include salivation, vomiting, respiratory difficulties, vertigo, hypothermia, cyanosis, and mild convulsion (Patty, 1963). Once widely used in medicine, occasional instances of self-medication are still reported and sometimes lead to chronic visual disturbances, hypertension, and gastrointestinal bleeding (NIOSH, 1977b).

The oral LD_{50} in rats is estimated at 725 mg creosote per kilogram body weight (mg/kg). The reported LD_{Lo} for dogs, cats, and rabbits is 600 mg/kg (Fairchild, 1977).

V. AQUATIC TOXICITY

Ellis (1943) found fish kills occurring at creosote concentrations as low as 6.0 mg/l in less than 10 hours. Applegate, et al. (1957), using small numbers of subjects, found that concentrations of 5.0 mg/l produced no mortalities in rainbow trout (Salmo gainneri), bluegill (Lepomis macrochirus), or lamprey larvae (Petromyzon marinus).

The 8-day LD_{50} of a 60:40 mixture of creosote and coal tar in bobwhite quail (Colinus virginianus) was reported to be about 1,260 ppm; in the mallard duck (Anas platyrhynchos), 10,388 ppm. The 24-hour 50 percent medium tolerance limit (TL_{50}) of the creosote/coal tar mixture was 3.72 ppm in rainbow trout (Salmo gainneri) and 4.42 ppm in the bluegill (Lepomis macrochirus). The 24-hour TL_{50} concentrations in goldfish (Carrasius auratus) and rainbow trout were 3.51 and 2.6 ppm, respectively (Webb, 1975).

VI. EXISTING GUIDELINES AND STANDARDS

The Office of Toxic Substances of EPA has issued RPAR on creosote and is continuing preregulatory assessment under Section 6 of the Federal Insecticide, Fungicide and Rodenticide Act.

A time-weighted average creosote concentration of 0.1 mg/m^3 has been recommended for occupational air exposure.

The aquatic toxicity rating for creosote is reported as TLm_{96} = 10-1 ppm (Fairchild, 1977).

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